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PRODUCING FEED AND FLOUR FROM WHITE POTATOES WITH STEAM TUBE DRIERS

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SUMMARY

Based on pilot-plant experience, methods are described for the use of steam tube driers in producing stock feed and flour and meal from ground, raw white potatoes. A plant processing 75 tons of potatoes daily, would produce about 17.3 tons of feed, at a cost of about $24.40 per ton. Such a plant would cost approximately $80,000. For the manufacture of flour and meal, an investment of about $87,500 would be required to make 16.6 tons daily. at a cost of about $39.00 per ton. These estimates are based on 170 days operation and include all costs except that of the potatoes and sales expense.

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INTRODUCTION

The recurring surpluses of white potatoes and the large number of culls have given rise to a need for cheap methods of converting them to a stable form in which they may be conveniently stored, shipped, and used for feed or industrial chemicals. This circular describes such a method.

This year part of the surplus will be used to supply the demand for about 448 million pounds of potato flour and meal required by the Commodity Credit Corporation for export. Since our normal, annual capacity for producing potato flour is only 35 million pounds, it was necessary to develop methods for quickly producing the much-needed flour. Bureau of Agricultural and Industrial Chemistry AIC-190, "Utilization of Idle Equipment in Distilleries for Production of White Potato Flour," describes such a method developed at the Eastern Regional Research Laboratory. Another simple method is described here. This method also uses equipment which may be idle in distilleries or other plants or which can be readily assembled.

PRODUCTION OF FEED

The equipment described below is that required for a factory processing 75 tons of potatoes in 24 hours, producing 17.31 tons of feed containing 10 percent moisture. This yield is based on a 2 percent loss of potatoes during processing. A diagrammatic flow sheet of the process is shown in Figure 1.

Washing: The potatoes are generally conveyed from freight cars or storage bins into the plant by water in a flume. They pass first to the washer. A washer such as that ordinarily employed in potato starch factories is well suited for this purpose. This consists of a U-shaped trough divided into sections and equipped with rotating paddles, which keep the potatoes in rapid motion and lift them from one compartment to the next. The stones and much of the dirt settle in the bottom of the trough and are periodically removed by flushing. A trough approximately 2-1/2 feet in diameter and 25 feet long with four compartments will properly wash at least 75 tons of potatoes in 24 hours, using about 25 gallons of water per minute.

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Grinding: To reduce the potatoes to a form suitable for drying, they are ground in a hammer mill equipped with a screen having holes 1/4 inch in diameter. Ordinary blunt hammers may be used. One mill 6 inches wide by 12 inches in diameter driven with a 7-1/2-horsepower motor, should have sufficient capacity. The speed of the mill should be sufficient to give a hammer tip speed of about 6,500 feet per minute. Much higher tip speeds may require a coarser screen.

Mixing and Drying: The ground potatoes will contain on the average 21.2 percent solids[5] and 78.8 percent moisture. To prevent the material from sticking to the tubes of the drier, the moisture must be reduced to about 43 percent. This is accomplished by continuously recycling a sufficient quantity of the dried product and mixing it with the moist feed. It is important that the dry product and the ground potatoes be mixed thoroughly before they enter the drier. A paddle-type mixer-conveyor 2 feet in diameter and 20 feet long and driven by a 3-horsepower motor should be satisfactory. A sufficient quantity of dried material must be provided before the drier is put into operation. Thereafter, recycling 1.1 pounds of the dried product containing 10 percent moisture per pound of ground potatoes containing 78.8 percent moisture will maintain a moisture content of 43 percent going to the drier. A steam tube drier handling this product will evaporate about 1.4 pounds of water per square foot of tube heating surface per hour, when steam is used at a pressure of 100 pounds per square inch. Thus for a factory of this size, approximately 3,600 square feet of tube heating surface will be required. This can be obtained by using two steam tube driers 6 feet in diameter by 35 feet long.

Bagging: That portion of the dried material not required for recycling is drawn off and bagged. Ordinary paper shipping bags, each holding approximately 100 pounds, may be used. The product is a dark granular material suitable for feed. It has a bulk density of about 45 pounds per cubic foot.

Investment: A factory costing approximately $80,000 (Table I) could produce about 17.3 tons of product per 24-hour day, at a cost of about $24.40 per ton (Table II). This figure includes all costs except that of the potatoes and sales expense for the product.

Alternate Method: One might logically inquire why the ground potatoes could not be pressed to reduce drying costs. Although such a step is entirely feasible (if about 0.8 percent lime is added), it is not generally desirable because the press effluent may constitute a stream contamination problem. Furthermore, up to 20 percent of the total solids in the potato may be lost in this effluent, a loss which would more than offset any economy in drying. Although some of the insoluble solids in the effluent might be recovered by settling, cost calculations indicate that it is cheaper not to press.

[5] MORRISON. FEEDS AND FEEDING. 20TH EDITION. P. 970 THE MORRISON PUBLISHING COMPANY. ITHACA. NEW YORK. 1939.

FEED FROM DRIED WHITE POTATOES

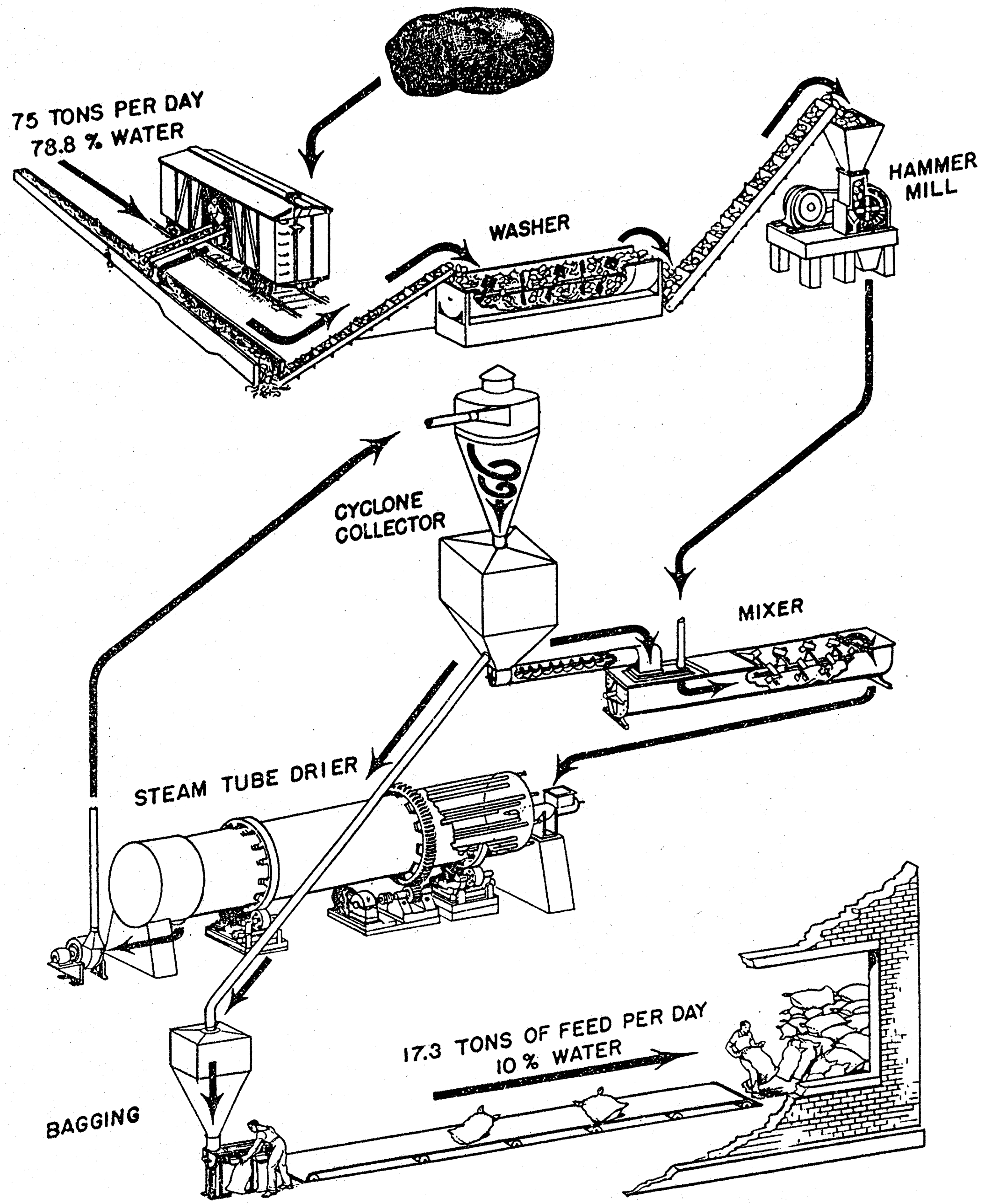

FIGURE 1.

PRODUCTION OF FLOUR AND MEAL

The same basic method described for the production of feed can be adapted to the production of potato flour and meal. This product will be slightly more cream colored than the highest quality potato flour made from cooked, peeled potatoes. It compares favorably with flour now being produced commercially with drum driers from cooked unpeeled potatoes.

The various steps are the same as those described for the production of feed with the following exceptions:

Because the product is to be used for food, the washed potatoes would have to be sorted to remove spoiled parts. Sulfur dioxide should be added to the ground potatoes to maintain a good color, and the moisture content must be reduced to not more than 9 percent. The dried product must also be ground and screened to produce flour or meal. Figure 2 is a diagrammatic flow sheet of the process.

The sulfur dioxide required to maintain the color is not more than 0.075 percent of the wet weight of the potatoes. The sulfur dioxide treatment can be carried on effectively in a wooden tank 4 feet in diameter and 5 feet high, equipped with a bronze turbine-type agitator. The sulfur dioxide can be fed continuously through a flowmeter at a rate commensurate with the rate of ground potatoes entering the tank. Since the average retention time is about half an hour, the tank also serves as a reservoir to equalize discrepancies in operating rates. The ground potatoes are delivered from the tank to the mixer by a positive delivery pump.

The moisture content must be reduced in the drier to not more than 9 percent. A drier handling this product will evaporate about 1.3 pounds of water per square foot of tube heating surface per hour when steam is used at a pressure of 100 pounds per square inch. Two driers 6 feet in diameter, 35 feet long and each having an evaporative area of 1,800 square feet will handle 75 tons of potatoes in 24 hours, making 16.6 tons of product. The lower yield of flour, as compared with that of feed, results from a higher loss of solids (5 percent) in the preparation of the food product and from its lower moisture content.

When mixed with 0.075 percent sulfur dioxide, the ground potatoes have a pH of about 5.8. Some of the sulfur dioxide driven off in the drier will be dissolved in the water which condenses in the drier stack. This will result in corrosion of the stack if it is not constructed of metal resistant to sulfur dioxide corrosion. Manufacturers who propose to use this process beyond the present emergency demand for flour should replace the stack, when required, with one constructed of such metal.

To produce flour and meal, the dried product must be ground in a hammer mill. One mill 6 inches wide by 12 inches in diameter equipped with blunt hammers and driven with a 7-1/2 horsepower motor should have sufficient capacity. The size of the holes in the hammer mill screen and the speed of the mill will be governed in part by the relative proportions of meal and flour desired. The choice may also be influenced by the moisture content and friability of the product.

The ground product must be screened. A vibrating screen driven by a 3-horsepower motor and equipped with 30-mesh and 70-mesh screens each 6 feet long and 3 feet wide, should be satisfactory. The ground product is fed to the 30-mesh screen, which is placed over the 70-mesh screen. Material passing through the 70-mesh screen is flour; that held on it is meal. The portion that does not pass through the 30-mesh screen is returned to the hammer mill.

The Commodity Credit Corporation specifications for flour may be obtained from Claude S. Morris, Potato Division, Fruit and Vegetable Branch, Production and Marketing Administration, U. S. Department of Agriculture, Washington 25, D. C.

Potentialities of the Process: For an investment of approximately $87,500 (Table I), 16.6 tons per day of potato flour or meal containing 9 percent moisture can be produced, at a cost of about $39.00 per ton (Table II). This figure includes all costs except that of the potatoes and sales expense for the product. This is considerably below the cost of producing potato flour by conventional means. Thus the potentialities of this method may well go beyond the present emergency. There should be an expandible domestic market for a potato flour which deviates only slightly in color from the best grade and costs only about half as much to make. The baking properties of this flour have not been determined. They may be different from that of flour made from cooked potatoes. However, its utility in other fields, such as dehydrated soups, is unquestioned. The shelf life of flour made by the method described here has not been determined. It may be shorter than that made from cooked potatoes since the flour has not been exposed to the higher temperatures incident to cooking.

Should a still lighter colored flour be required for domestic use, it can be made by drying in two stages (two driers in series) using steam at 100 pounds per square inch in the first drier and at 50 pounds per square inch in the second. Obviously, peeling the potatoes would also improve the color but at a significant increase in cost.

Alternate Method: In general, water can be expressed more cheaply than it can be evaporated. Consideration was therefore given to expressing sufficient water from the ground potatoes, after treating them with sulfur dioxide, to prevent sticking in the drier without recycling. It was found that the critical moisture content of the material to the drier was about 56 percent, instead of 43 percent, the moisture content of unpressed potatoes. However, it is not economically feasible to reach 56 percent moisture in continuous-type rotary presses. Batch-type cider presses capable of developing 200 pounds pressure per square inch must be used, and the labor costs for this are high. Moreover, about 15 percent or more of the potato solids are lost, including valuable proteins, starch and sugar. Disposal of the press effluents may also constitute a stream-pollution problem. Thus although the color of flour from pressed ground potatoes which have not been recycled during drying is slightly superior to that of the unpressed, recycled product, in our opinion the additional cost of pressing is not justified. It is estimated that pressing instead of recycling would cost about an additional $2 per ton of product.

FLOUR AND MEAL FROM DRIED WHITE POTATOES

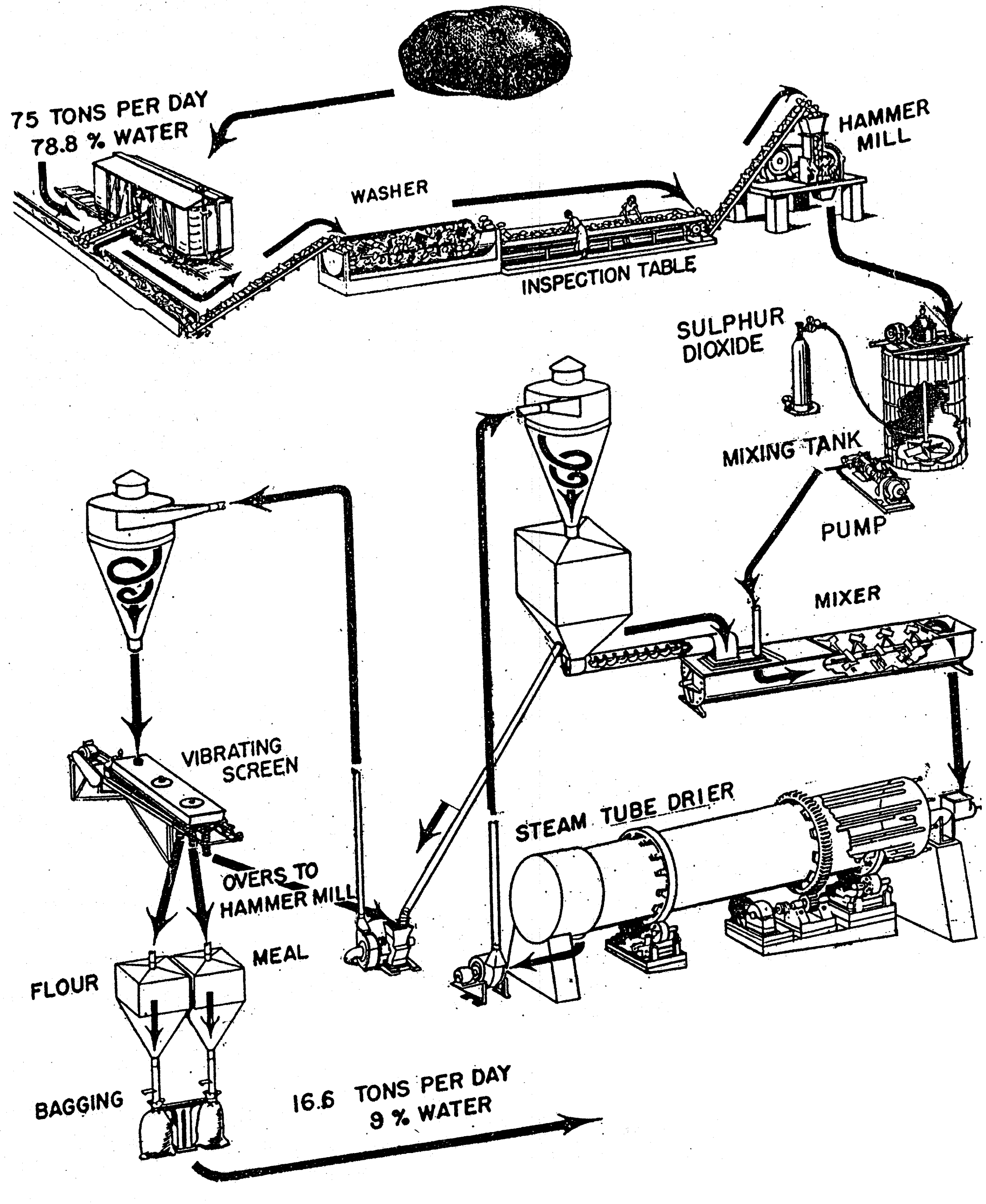

FIGURE 2

COSTS

To have definite figures on all items entering into the cost calculations, a specific area for the plant was chosen. Long Island, New York, was selected because of its central location on the eastern seaboard and because of the large quantities of potatoes grown in that vicinity.

The following assumptions are made. Both feed and flour plants would operate 170 days yearly, and each would process daily 75 tons of potatoes which contain 21.2 percent solids[5] and 78.8 percent moisture. Based on a 2-percent loss of potatoes during processing, the feed plant would produce daily 17.31 tons of product having 10 percent moisture. Based on 5-percent loss of potatoes during processing, the flour factory would produce daily 16.60 tons of product having 9 percent moisture.

It is further assumed that no one would go into the production of potato flour or feed without already possessing some of the facilities. The estimates therefore, are based on the assumption that an already established business will provide such items as storage, office facilities and watchmen. Since the manager would also operate the new enterprise, a charge of $10.00 per day throughout a 300-day year is made to cover his services to the process. One operator on each of the two shifts, 4:00 to 12:00 and 12:00 to 8:00, is given 50 cents per hour additional to act as foreman, making a total daily charge of $8.00. Thus, the total for supervision is $25.65 per day. One-quarter of the time of a secretary-stenographer-clerk of the already going business is charged to the new process. This represents a charge of $3 09 per operating day. For the operating period of 28 weeks, one-quarter of the time of two watchmen at $25.00 per week each is charged, $2.06 per operating day.

Owing to the nature of the operation, with its long idle period, the investment is amortized at 8 years except that for the building for which 10 years is allowed. For the same reason, maintenance, repairs, and renewals are charged at a relatively high rate.

No provision is made for vacations, as the plant operates only 170 days a year.

No general cost estimate of this type will exactly fit the conditions of any prospective manufacturer. With an understanding of the assumptions upon which the estimate is based, however, a manufacturer should be able to make a reasonable estimate of his own costs.

It should be emphasized that the capital costs given here and the cost per ton for producing the products are based on the use of a new building and the purchase and installation of new equipment. When idle equipment, such as steam tube driers, is available, the capital costs will be proportionately less, and hence the overall costs will be somewhat less than those shown.

Table I. **CAPITAL COSTS**

	Feed	Flour and Meal
Building, galvanized iron on structural steel, 50 x 60 ft. and 25 ft. high	$15,029.60	$15,029.60
Boiler, 290 h.p., housed and ready to run	15,933.50	16,010.50
Equipment:		
Flume, wood, 12 in. x 18 ft. and 9 in. high	85.20	85.20
Conveyor, belt, 3-ft. centers, 12 in. wide, with cleats and side rails	498.60	498.60
Washer, 25 ft. x 30 in. x 30 in., with 4 compartments	750.83	750.83
Conveyor, belt, 14 in. x 25 ft. with cleats and side rails	591.30	591.30
Hammer mill, 6 in. x 12 in. dia., with 1/4-in.-screen, with 7-1/2-h.p. motor	668.19	668.19
2 Driers, each 6 ft. dia. x 35 ft., 1800 sq.ft. of heating surface	20,020.00	20,020.00
Cyclone separator, rated capacity 5300 cu.ft. per min.	895.00	895.00
Blower to cyclone, standard E, single width, approx. 5600 cu.ft. per min. with 5-h.p. motor	434.47	434.47
Conveyor, screw tube, 6 ft long, with 1/2-h.p. motor	244.48	244.48
Bagging bin, wood, 3 ft. dia. x 5 ft. deep	115.00	115.00
Bagging head, sheet metal breeches	20.00	20.00
Pump, centrifugal, 100 gal. per min., 50-foot head	277.00	277.00
Bin under cyclone, steel tank, 4 ft. x 6 ft. deep	354.77	354.77
Mixer-conveyor, paddle type, 2 ft. dia. x 20 ft. long, with 3-h.p. motor	1,643.23	1,643.23
Bin for potatoes, wood, 25 x 15 ft. and 8 ft deep	482.37	482.37
Inspection belt and feeder, belt 18 in. x 12 ft.		590.50
Screen, vibrating, 3 ft. x 6 ft., with 3-h.p. motor		1,321.94
Hammer mill for dried product, 6 in. x 12 in. dia., with 7-1/2-h.p. motor		696.94
Blower, standard A, single width, approximately 1700 cu.ft. per min., with 2-h.p. motor		255.30
Cyclone separator, rated capacity 1635 cu.ft. per min.		405.00
Tank for sulfur dioxide treatment, wood, 4 ft. dia x 5 ft. high		127.50
Agitator, turbine type, bronze, with 5-h.p. motor		1,043.02
Pump, positive delivery, to handle 6250 lb. per hr., with 1-1/2-h.p. motor		308.85
Freight for equipment	531.96	607.00
Erection of equipment	6,782.51	8,109.12
Piping and duct work	834.75	851.90
Erection of piping and duct work	648.31	665.17
Heating, installed	819.58	819.58
Lighting, installed	394.78	394.78
Contingencies	4,000.00	4,371.59
Engineering fees	8,006.16	8,743.18
Total	$80,061.59	$87,431.91

Table II. COST SHEET

Based on a 24-hour Day

	Feed		Flour and Meal	
Material	-		-	
Potatoes	-		-	
Sulfur dioxide	-		$ 18.00	
Labor	$ 90.86		179.66	
PRIME COST		$ 90.86		$197
FACTORY OVERHEAD				
Indirect materials				
Bags	34.62		132.80	
Indirect labor				
Supervision	25.65		25.65	
Factory clerk	3.09		3.09	
Indirect expense				
Insurance, public liability and fire	2.35		2.57	
Workmens Compensation	1.34		2.45	
Unemployment Insurance	3.59		6.25	
Social Security	1.18		2.08	
Taxes	9.42		10.29	
Interest on investment	11.77		12.86	
Depreciation	58.99		60.72	
Maintenance, repairs and renewals	28.26		30.86	
Power	13.19		18.67	
Steam	133.02		135.14	
Water	-		-	
Freight and cartage into plant	-		1.95	
Miscellaneous factory expenses	5.00		5.00	
Total factory overhead		331.47		450
FACTORY COST		422.33		648
Cost per ton		24.40		39